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PATENT SPECIFICATION

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(54) IMPROVEMENTS IN AND RELATING TO BORE HOLE DRILLING

(71) We, COMPAGNIE FRANCAISE DES PETROLES, a French corporate body, of 5 rue Michel-Ange, Paris 16 ème, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with exploratory drilling and in particular to the protection of a drilled hole against caving in and ingress of water.

Known methods, in spite of the progress achieved, all have the common characteristic of protecting the drilled hole against caving in of the strata passed through by means of tubes which are sent down as the drilling descends. This type of protection which is costly, due both to the time required to place the tubes in position and the manchandling involved and to the cost of the tubes used, is particularly troublesome in the case where drilling methods, known as rotary drilling methods are employed, because of a loss of power, due to rubbing of the drilling tool drive shaft against the walls of the bore hole, is added to the above disadvantage. This loss of power may be considerable because this shaft may be as much as several miles in length. Furthermore, when the tools require changing it is necessary to raise the drive shaft, which comprises lengths of rod screwed one into the other, and unscrew it thus increasing the cost price of this type of protection.

The method of bore-hole drilling called "flexidrilling" achieves a net advance over rotary methods because the drive shaft is replaced by a flexible armoured hose for the tool driving motor and the flexible hose can be wound up or unwound by means of a drum. In addition, the space taken up by the drilling platform can be reduced in size. However this method does not dispense with the need to protect the drilled hole using steel tubes to prevent caving in of the strata. Furthermore, it is essential to ensure a perfect seal round the flexible hose so as to avoid the considerable danger if an eruption occurs.

According to one aspect of the present invention there is provided a method of exploratory drilling comprising drilling a hole and moulding a tubing around the wall of the drilled hole simultaneously with drilling of the hole, the tube preventing caving in of the strata and ingress of water.

According to another aspect of the present invention there is provided a method of exploratory drilling comprising drilling a hole by passing a drilling tool downwardly through the earth, moulding a tubing around the wall of the drilled hole simultaneously with the downward movement of the drilling tool, to prevent caving in of the strata and ingress of water, wherein an expandable member carried by the drilling tool is expanded laterally against the moulded tubing so as to prevent relative movement between the expandable member and the tubing and a force is exerted between the stationary expandable member and the drilling tool to cause the drilling tool to progress downwardly.

Thus, on the surface, instead of having a large stock of pipes always available, which are assembled one to the other as drilling progresses, it is only necessary to have available a stock of moulding materials which are tipped into appropriate tanks, from which they are led into a tubing former connected with and above the drilling tool.

By use of this method the strata can be supported immediately after drilling.

The portion of tubing in the process of being moulded may be protected from the drilled strata by a sleeve which is moulded below it. This enables the tubing to be effectively protected during its moulding process because it is enough to ensure that the sleeve former and drilling tool holder are effectively sealed for the tubing former to be protected from the strata and, as a result, all water ingress.

According to a further aspect of the present invention there is provided apparatus for carrying out the above method comprising a drilling tool, a supporting body for supporting the drilling tool, a motor for rotating the tool and mounted below the supporting body, a tubing former on said body for forming the tubing and having an injection zone at its lower end and a feed circuit for feeding tubing moulding material to the injection zone of the former.

The invention will be more fully understood from the following description of an embodiment thereof, given by way of example only, with reference to the accompanying drawings.

In the drawings:

Figure 1 is a diagrammatic view in cross section of the lower part of an embodiment of a machine according to the invention;

Figure 2 is a diagrammatic view in cross section of a part of the machine of Figure 1;

Figures 3, 4 and 5 are diagrammatic illustrations of the means of advancing the tool of the machine of Figure 1 in three different stages;

Figure 6 is a diagrammatic illustration of the supply circuit for the materials used in the machine of Figure 1;

Figure 7 is a diagrammatic illustration of the drilling mud circuit of the machine of Figure 1; and

Figure 8 is the diagrammatic illustration of the main controls for controlling the descent of the machine of Figure 1.

The machine comprises a motor 1 driving a retractable drill tool 2 and which may be a turbine or an electric motor. It is lowered by means of a flexible hose 3 or similar means inside which are fitted all the circuits required to supply the motor, to supply the oil circuits controlling the progress of the drill and for mud circulation. In order not to uselessly overcrowd the drawing, only an oil feed channel 23, a mud circuit 4, a single material feed circuit 5 for moulding a sleeve 6 and a single material feed circuit 7 for moulding a tubing 8 are illustrated.

These various circuits are placed under the control of a control unit 9 below which a body 10 is located carrying two inflatable sleeves 11 and 12. Sleeve 11, fast with body 10, enables all the equipment illustrated to be supported after inflation whereas sleeve 12, fast with a cylinder 42, slides with the said cylinder up and down body 10 by means of sealing rings 13 and 14, thus enabling tool driving motor 1 and all the equipment to be moved after inflation of sleeve 12.

The equipment for making the sleeve 6 and tubing 8 comprises two tube formers 15 and 16 provided with heating element 17 and 18 and injection zones 19 and 20 receiving respectively the materials for making the tubing 8 through circuit 7 and for making sleeve 6 through circuit 5.

The material which is used for making tubing 8 may be of the resin or cement type having, for example, a resistance to compression greater than 2,500 bars and a resistance to traction greater than 700 bars over a temperature range of between 0° and 150°C, the viscosity being less than 70 poises.

As an example, tubing 8 may be made up of a polymerised epoxy resin. The thermohardening resin is injected at a pressure of approximately 30 bars above the pressure existing at the base of the drill. The resin is cooled by a ring 21, in which a cooling liquid, e.g. mud, circulates, thus preventing a risk of polymerisation in the injection zone 19. Heating element 17 and 18, on the other hand, ensure polymerisation of the injected material.

Sleeve 6, in the example chosen, is a silicone elastomer resin (trade name "Silastene") which is extruded and which possesses the characteristic of polymerising well in water. A retractable shield 22, consisting of an inflatable sleeve, which can be seen in the inflated position in Figure 2, ensures protection of sleeve 6 during its formation by preventing fragments or rock particles from being included in the sleeve, which, if included, might well become water ingress points.

Tube formers 15 and 16 are units which are inflated in the same manner as shield 22 by the oil circuit 23. To raise the tool-tube former assembly all that is necessary is to slightly deflate units 15 and 16.

The resin supply circuits used to make the protective sleeve 6 and tubing 8 are similar to those illustrated in Figure 6. For each type of resin to suit respectively sleeve 6 or tube 8 there is on the surface one tank 24 used for the preparation of the basic material and one tank 25 used for the preparation of the hardener. A vacuum pressure device illustrated diagrammatically by pipe 26 ensures that fumes from the material are extracted. Mixer 27 is designed to homogenise the resin base assembly, heated by heating element 28. The base added to the resin is designed to increase the resin's mechanical properties and its thermal conductivity. It may be, for example, of a metallic nature.

Tank 25, used for the preparation of the hardener, comprises in the same manner a vacuum pressure device, not illustrated, connected to pipe 29 for hardener fume extraction, and a heating element 30.

Pumps 31 and 32 are metering pumps incorporated in resin hose 33 and in hardener hose 34. Safety valves 35 and 36, enabling a return to be made to tanks 24 and 25 respectively in the event of abnormal pressure in flexible hose 3, are adjusted to

suit the drilling depth thus ensuring an injection pressure for the resins at formers 15 and 16 which is 30 bars higher than that at the bottom. Flexible hoses 33 and 34 are heated thus ensuring that the viscosity of the material is not lowered. A valve 37 enables the introduction of hardener into a static mixer 38 to be stopped. This allows static mixer 38 to be drained of hardener. In the event of a temporary stop in drilling, before valve 39, which controls the feed of resin to injection zones 19 or 20, according to whether tubing 8 or sleeve 6 is being made, is closed. It will be understood that two assemblies exist similar to that shown in Figure 6, one for the sleeve 6, the other for the tubing 8.

Thus it will be understood that circuits 5 and 7, illustrated in Figure 1, each comprise two channels, one for the resin and the other for the hardener, the channel for the latter being provided with a valve such as 37 located on the inlet side of a static mixer such as 38. Likewise, valves such as 39 control the flow of each of the resins and they are located one in channel 7 near injection zone 19 and the other in channel 5 near injection zone 20.

The advancement of drilling and the forming of tubing 8 and its sleeve 6 are carried out as illustrated diagrammatically in Figures 3 to 5. In Figure 3, sleeves 11 and 12 are illustrated deflated and inflated respectively. Sleeve 11 is fast with body 10 and descends with body 10 as a result of oil pressure, in the general circuit 23, exerted on piston 40, fast with body 10, under the control of control unit 9 (Figure 8). Oil entering the top part of cylinder 42 via circuit 41 pushes the piston down, sleeve 12 remaining firmly applied against tubing 8 by previous inflation of the sleeve. Thus, as tool 2 progresses downwards, body 10 descends relative to sleeve 12. Formers 15 and 16 fast with body 10 also descend and, during this movement, a certain amount of resin is extruded in zone 20 to form sleeve 6, the resin gradually polymerising in the regions of the heating element 18, whereas resin extruded in zone 19, the flow of which is different from the resin used in the making of sleeve 6, polymerises near heating element 17 to form tubing 8. It is of course understood that the quantities injected are in proportion to the downward progress of the tool and the thickness of the respective sleeve or tubing. For example, the sleeve 6 may be about 10 mm thick and the tubing 8 about 50 mm thick. The control unit 9 controls the supply of resins.

The tool continues to advance downwards until piston 40 reaches the bottom of cylinder 42, Figure 4. This leads to the immediate inflation of sleeve 11, Figure 5, which holds the body 10 while sleeve 12 is deflated to enable it to take up a lower position as the result of injection of oil into the part of cylinder 42 located below piston 40. The automatic inflation of sleeve 11 may be ensured by an electrical impulse from an end of stroke stop 58, the impulse being transmitted by wire 61 to control unit 9, Figure 8. As solenoid flap valve control circuits which control hydraulic feed to the hydraulic circuits are well known, details of the various circuits ensuring inflation and deflation of the sleeves have not been illustrated. Thus, during a period of time which may be very short, sleeve 12 moves down to a lower level so that when the top of cylinder 42 is close to piston 40, all that is necessary is to apply oil under pressure once again inside sleeve 12 and release the pressure inside sleeve 11 to return to the initial conditions illustrated in Figure 3. For this purpose an end of stroke stop 59 may be used which sends a releasing impulse by wire 60 to control unit 9 (Figures 1 and 8). In Figure 8, then, are found the oil circuit 23, resin supply circuit 5 and 7 and mud circuit 4 comprising a down channel 4*a* and an up channel 4*b* in zone Z, Figure 7.

A high pressure pump 45 supplies the oil necessary to inflate formers 15, 16, shield 22 and sleeves 11 and 12. A first circuit 43 leads to controls C15, C16 and C22 for inflating formers 15, 16 and shield 22. In the same way a second circuit 44 leads to controls C11 and C12 for sleeves 11 and 12. The assembly of circuits 48, 49 and 50 controlling controls C15, C16, and C22, and circuits 46 and 47 controlling controls C11 and C12 are placed under the control of the general control 51 for advancing or stopping the forming machine and in consequence piston 40, the movement of which depends on the oil fed via circuit 41. Circuit 41, serving channels C42*a* and C42*b* controlled by control channels 62 and 63 from the general control 51, enables, via channel C42*a*, the drill to advance downwards and the sleeve 6 and tubing 8 forming machine to descend simultaneously, and enables, via channel C42*b*, cylinder 42 to descend after deflation of sleeve 12. Wires 61 and 60 transmit the impulses sent out by the end of stroke stops 58 and 59 to the general control 51 in order to control the automatic setting in motion of the inflating and deflating operations for sleeves 11 and 12 via control channels 46 and 47. The mud circuit 4 is also placed under the control of controls CE, CF and CG for three valves E, F, G (Figure 7), these controls being placed under the control of control unit 51 by channels 64, 65 and 66. Valves E and F may be closed in the event of the forming machine being stopped or due to detection of a high pressure zone by detector 53 coupled to control unit 51 by C53. In this illustration, the zone including

the tube making machine, and the inflatable sleeves, has been indicated by the letter Z. The moulding zone has been indicated by the letter M. As far as the mud circuit is concerned, it is seen that it is fed in by flexible hose 3 and returned by channel 4 in annular section A. Supply circuits 5 and 7 for resins and hardeners are placed under the control of controls C35, C36 and C'35, C'36 as well as controls C37 and C'37 controlling valves 37 for the hardener circuits and C 39 and C'39 controlling valves 39 for the resins supply. A channel 54 connects control unit 51 to controls C35 to C'36 thus bringing the resin flow under a control relative to the speed of advance by any desired method, channel C53 also enabling this flow to be brought under a control relative to the pressure existing at the bottom of the drilling transmitted by pressure sensor 53 by any desired method. Control unit 51 is operated consequently from the surface by line T.

In addition to these controls, a dotted line C'53 has been illustrated to show a special connection the object of which is to send a signal set in motion by very high pressure or an eruption. This signal, by means of connection 55, enables the flow of resins to be stopped and heating of heating elements 17 and 18 of formers 15 and 16 to be switched off, by means of connection 56 for controlling the closure of the mud circuit valves E and F and by means of connection 57 for controlling the inflation of sleeves 11 and 12, with the object of locking the machine and proceeding to insert a cement plug.

As these various circuits can be of any form and as they are not part of the invention insofar as the application of the units, which can be obtained from trade sources, is concerned, it has not been deemed necessary to illustrate in detail each control, whose structure may take any form. The control of resin flow limits such flows to a rate of increase of 10%. Thus, even if the bore hole passes through an underground cavern which may be present in the strata, the increase in resin flow will only lead to a slight increase in sleeve and tubing thicknesses in the region of the cavern. Again it will be noted that although such caverns are usually filled with water, it is always possible to make the sleeve because the material thereof is selected to be able to polymerise in water. As the tubing is protected by the sleeve, the tubing can still be moulded normally.

If drilling must be interrupted, the flow of hardener is stopped by means of valves 37 and the resin circuits are drained of hardener. If drilling recommences, a start is made by machining the inner wall of the bottom part of the tubing a few yards above the bottom of the drilling. Thus the retractable tool 2, during its descent, advances its head gradually downwards in the tubing and cuts a wall in a truncated shape until meeting up with the protecting sleeve. This truncated shape cutting may alternatively be carried out by a boring sleeve, this sleeve being located just above the drilling tool. If a cement plug has been poured, it is broken up by means of the drilling tool, the pressure at the bottom being contained by the clamps on the machine in the conventional way. When former 15 reaches the point where the truncated portion commences, resin is injected without hardener thus forcing out the mud, then the controls are set for the feed of hardener and resin. While the machine is descending and as soon as former 16 reaches the bottom end of the truncated cone, the controls are set for forming the outer sleeve. In this manner a perfect joint is made between the earlier tubing and a new section of tubing, the end of the new sleeve being held between two truncated layers of tubing resin. Thus the machine constructed enables a perfect tubing joint to be made after an interruption.

It is self-evident that the thermohardening materials which may be used to form the sleeve and tubing can be of any sort provided that their mechanical properties are sufficient to take the place of conventional tubing. Thus the invention encompasses the case of forming a tubing 8 without making a sleeve 6.

In addition to the above-mentioned applications, that is to say bore-hole drilling with simultaneous forming of tubing continuously, the stopping and the restarting of the downward advance, the machine can also be used to make the internal sleeveing of tubes even if filled with water or to make the internal sleeving of a punctured or completely oxidised tube.

Finally, the controls for advancing the tool downwards by means of sleeves 11, 12 and cylinder 42, can be reversed to return the assembly to a desired depth, as for example when restarting the tubing process with the object of connecting it to the previously formed portion.

WHAT WE CLAIM IS:—

1. A method of exploratory drilling comprising drilling a hole and moulding a tubing around the wall of the drilled hole simultaneously with drilling of the hole, the tube preventing caving in of the strata and ingress of water.

2. A method of exploratory drilling comprising drilling a hole by passing a drilling tool downwardly through the earth, moulding a tubing around the wall of the

drilled hole simultaneously with the downward movement of the drilling tool, to prevent caving in of the strata and ingress of water, wherein an expandable member carried by the drilling tool is expanded laterally against the moulded tubing so as to prevent relative movement between the expandable member and the tubing and a force is exerted between the stationary expandable member and the drilling tool to cause the drilling tool to progress downwardly.

3. A method according to either claim 1 or claim 2, in which moulding of the tubing is carried out by extruding mouldable material therefor from an injection zone around the wall of the drilled hole, the injection zone being gradually moved downwardly parallel to the drilling axis.

4. A method according to claim 3, in which the mouldable material is a thermohardening material which is heated after extrusion to harden the extruded tubing.

5. A method according to claim 4, in which the extruded material is cooled prior to being heated.

6. A method according to any of the preceding claims, including moulding a sleeve directly against the wall of the drilled hole prior to moulding of the tubing.

7. A method according to claim 6, in which moulding of the sleeve is carried out by extruding mouldable material therefor from an injection zone around the wall of the drilled hole, the injection zone being gradually moved downwardly parallel to the drilling axis, and heating the sleeve material after extrusion.

8. A method according to either claim 6 or claim 7, in which the material for the sleeve is such that polymerisation thereof takes place in the presence of water.

9. A method according to claim 8, in which the material for the tubing is such that polymerisation thereof takes place screened from water.

10. A method according to any of claims 6 to 9, in which the moulding of the sleeve is carried out screened from rock fragments or particles.

11. A method according to any of claims 6 to 10, in which the rates of flow of the injected materials are controlled so as to maintain a constant thickness of both tubing and sleeve when passing through an underground cavern.

12. A machine for carrying out the method of claim 1, comprising a drilling tool, a supporting body for supporting the drilling tool, a motor for rotating the tool and mounted below the supporting body, a tubing former on said body for forming the tubing and having an injection zone at its lower end and a feed circuit for feeding tubing moulding material to the injection zone of the former.

13. A machine for carrying out the method of claim 2, comprising a drilling tool, a supporting body for supporting the drilling tool, a motor for rotating the tool and mounted below the supporting body, a first inflatable annular sleeve fixed to the body, a second inflatable annular sleeve movably attached to the body, a hydraulic jack to control the movement of the second annular sleeve with respect to said body, a tubing former on said body for forming a tubing, said former having an injection zone at its lower end; and feed circuit for feeding tubing moulding material to the injection zone of the tubing former.

14. A machine according to either claim 12 or claim 13, comprising a sleeve former on said body and positioned below the tubing former, the sleeve former having an injection zone at its lower end, and a feed circuit for feeding sleeve moulding material to the injection zone of the sleeve former.

15. A machine according to any of claims 12 to 14 in which the or each former is inflatable and includes heating means.

16. A machine according to claim 15, in which the tubing former includes cooling means between the injection zone and heating means.

17. A machine according to any of claims 14 to 16, in which said body carries an inflatable annular shield immediately below the injection zone of the sleeve former.

18. A machine according to claim 13 or any of claims 14 to 17 when dependent on claim 13, in which the second inflatable sleeve is mounted on a cylinder the ends of which have seals slidable on an external cylindrical portion of the body, the body carrying a ring dividing the interior of said cylinder into two annular chambers, inlet and outlet orifices for feeding oil to said chambers being provided.

19. A machine according to any of claims 12 to 18, in which the or each feeding circuit for moulding material comprises a channel for a thermohardening resin or cement and a channel for a hardener, said channels feeding into a static mixer immediately upstream of the injection zone of said former, a first valve controlling supply of hardener to said static mixer and a second valve controlling supply of the mixed materials to said injection zone.

20. A machine according to any of claims 13 to 19 in which an upper part of said body includes control means for controlling mud circulation, operating oil circulation, moulding material circulation and heating circuits.

21. A machine according to claim 20, including a pressure sensor for sensing the

pressure in the bottom of a hole being drilled and for continuing the flow of moulding material.

22. A machine according to claim 21 when dependent on claim 19, in which said control means is adapted to act on reception of an impulse from the pressure sensor such that, when the pressure sensed by the sensor exceeds a predetermined value, said control means causes the delivery of mud to the drill tool and to stop, both the sleeves to inflate, the or each hardener delivery valve to close, the or each delivery valve for the moulding material to close at the outlet from the or each static mixer once the mixer has been drained of hardener, the switching off of the or each heating element circuit and a halt to the machine's progress downwards.

23. A machine according to any of claims 20 to 22, in which said control means includes means for automatically setting in motion the inflation of the first sleeve deflation of the second sleeve and its descent under the control of a first end of stroke stop in said hydraulic jack, a second end of stroke stop being connected to means for setting in motion inflation of the second sleeve, deflation of the first sleeve and the filling of the other annular chamber in said hydraulic jack.

24. A method of exploratory drilling substantially as herein described.

25. A machine for exploratory drilling substantially as herein described with reference to the accompanying drawings.

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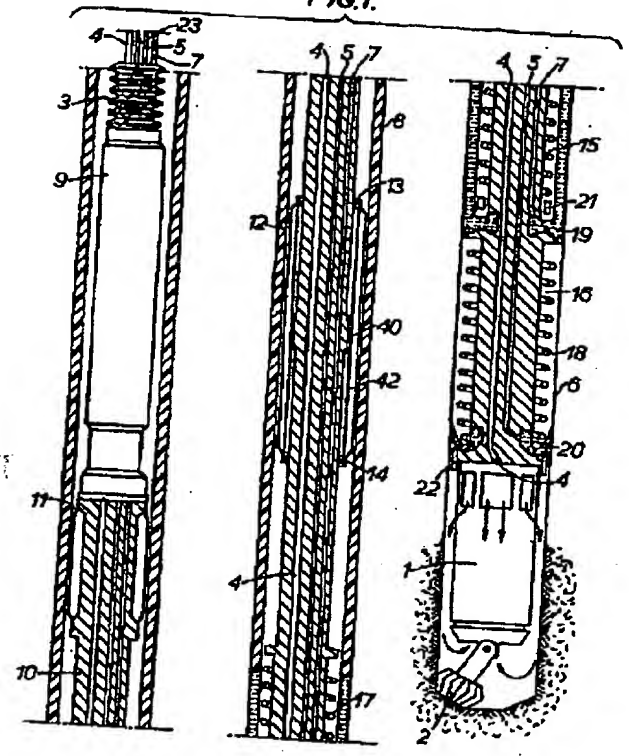
Sheet 1

FIG. 1.



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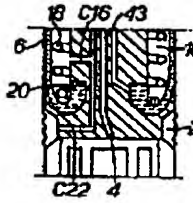

FIG. 2.

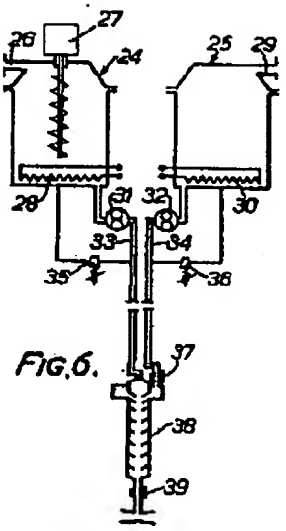

FIG. 6.

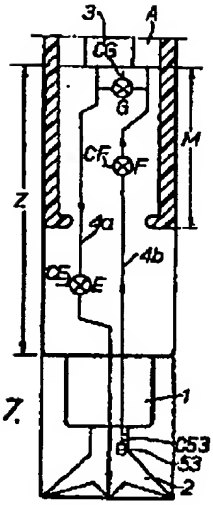

FIG. 7.

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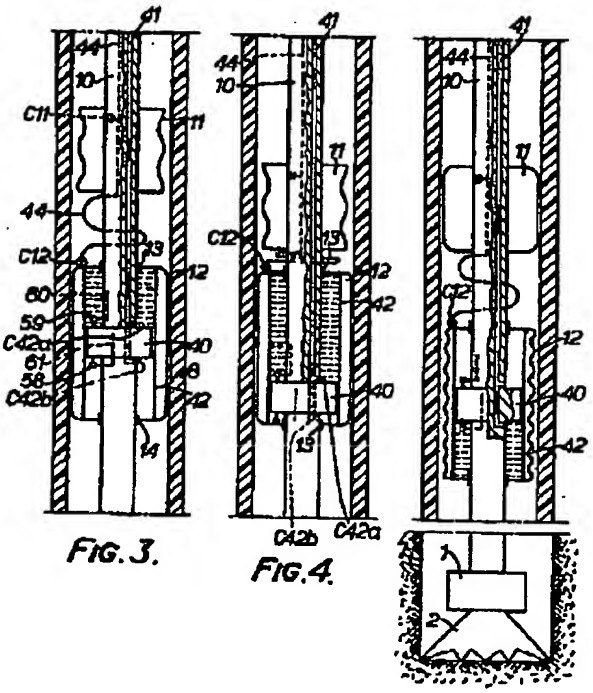

FIG. 3.

FIG. 4.

FIG. 5.

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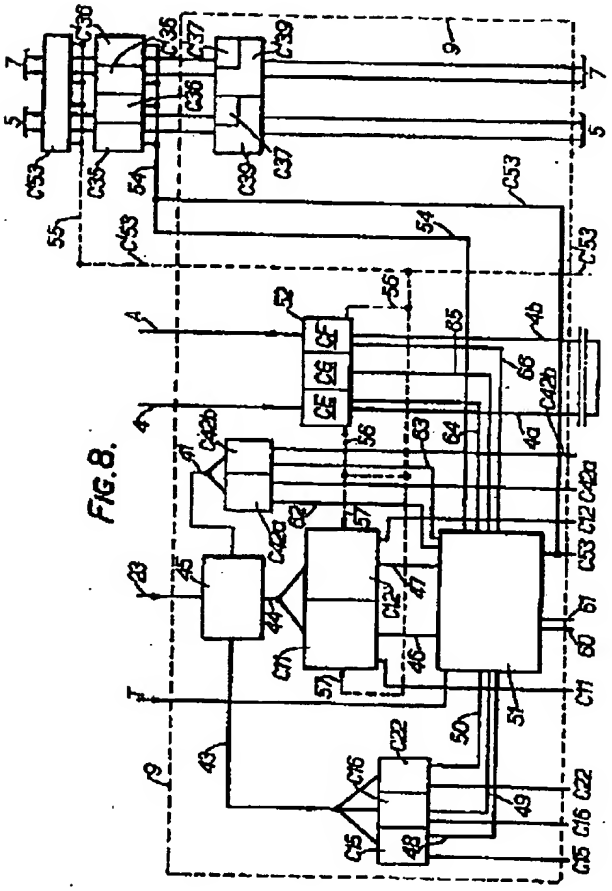

FIG. 8.